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(54) Turbine of exhaust gas turbocharger

(57) The turbine inflow passage 3 is divided into sub-channels 5 by annular partition(s) 4, and at least one annular shutter 11, 12 is mounted coaxially with the annular partition(s) and slidably along its axis for closing one or more of the sub-channels during starting and under partial load of the internal combustion engine whereby the exhaust-gas flows at higher velocity through the sub-channel(s) left open; for full load operation all the sub-channels are opened. With coaxial annular partition(s) and shutter(s) optimum inflow conditions prevail in all operative conditions. The annular shutter(s) and partition(s) are preferably coaxial with the turbine axis. In use, radially inner sub-channel(s) are closed in preference to radially outer ones for better turbine efficiency. In a two-stage turbine one of the sub-channels may by-pass the first stage.

Fig.1

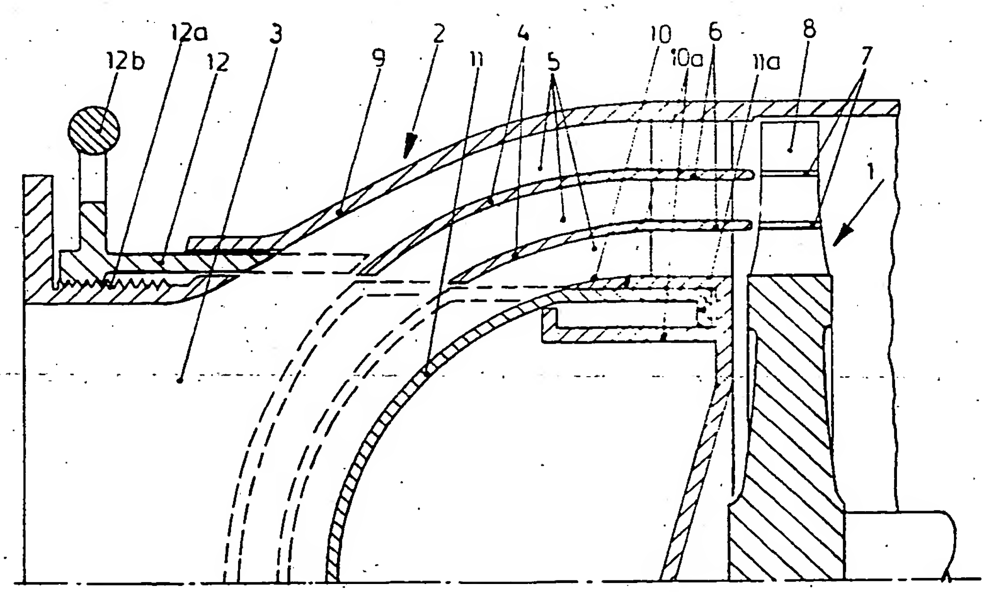

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Fig.1

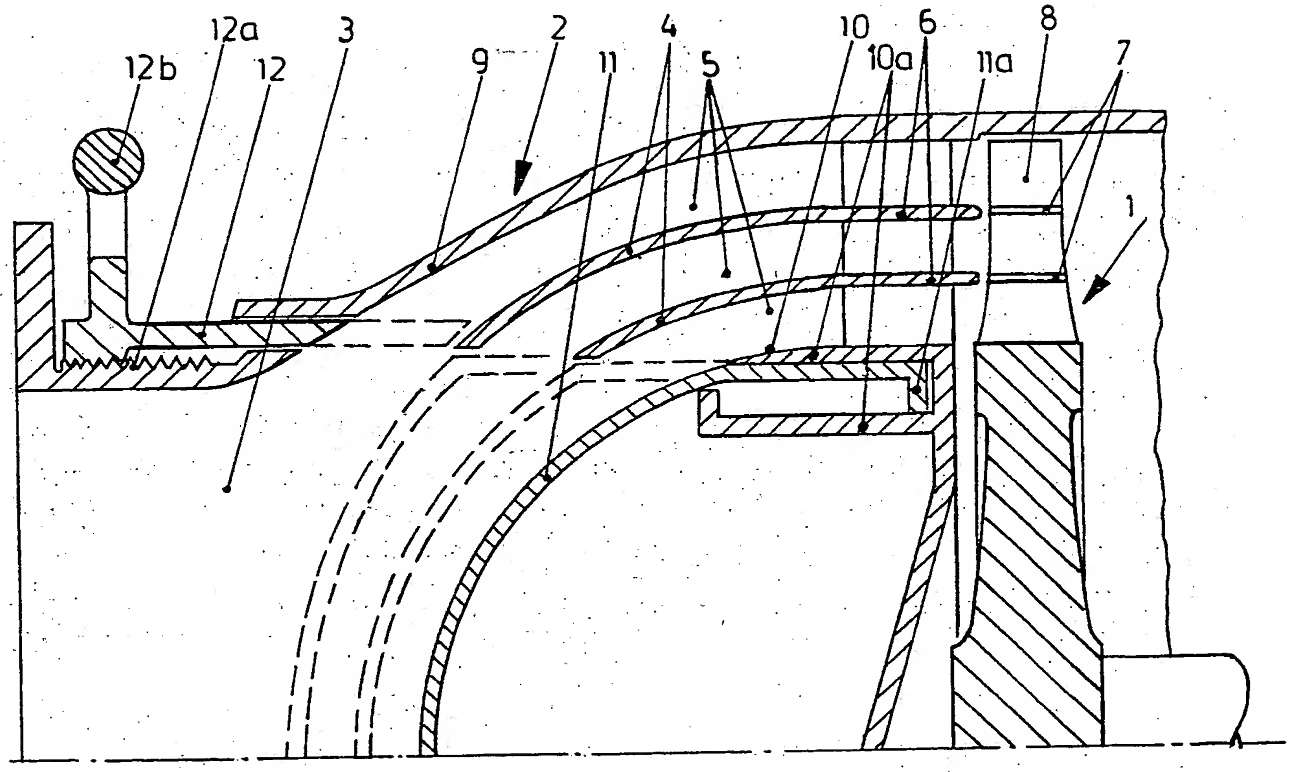
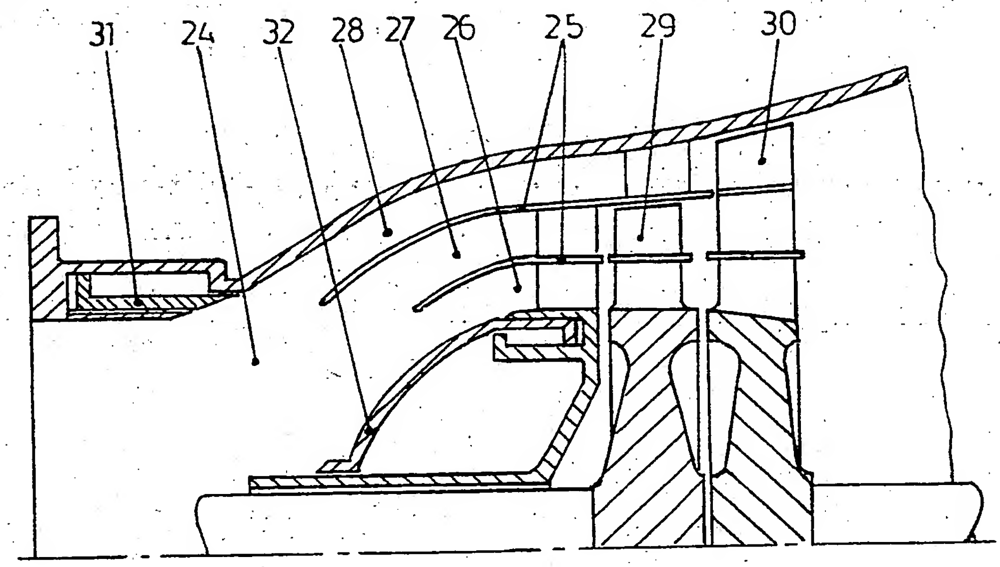


Fig.3



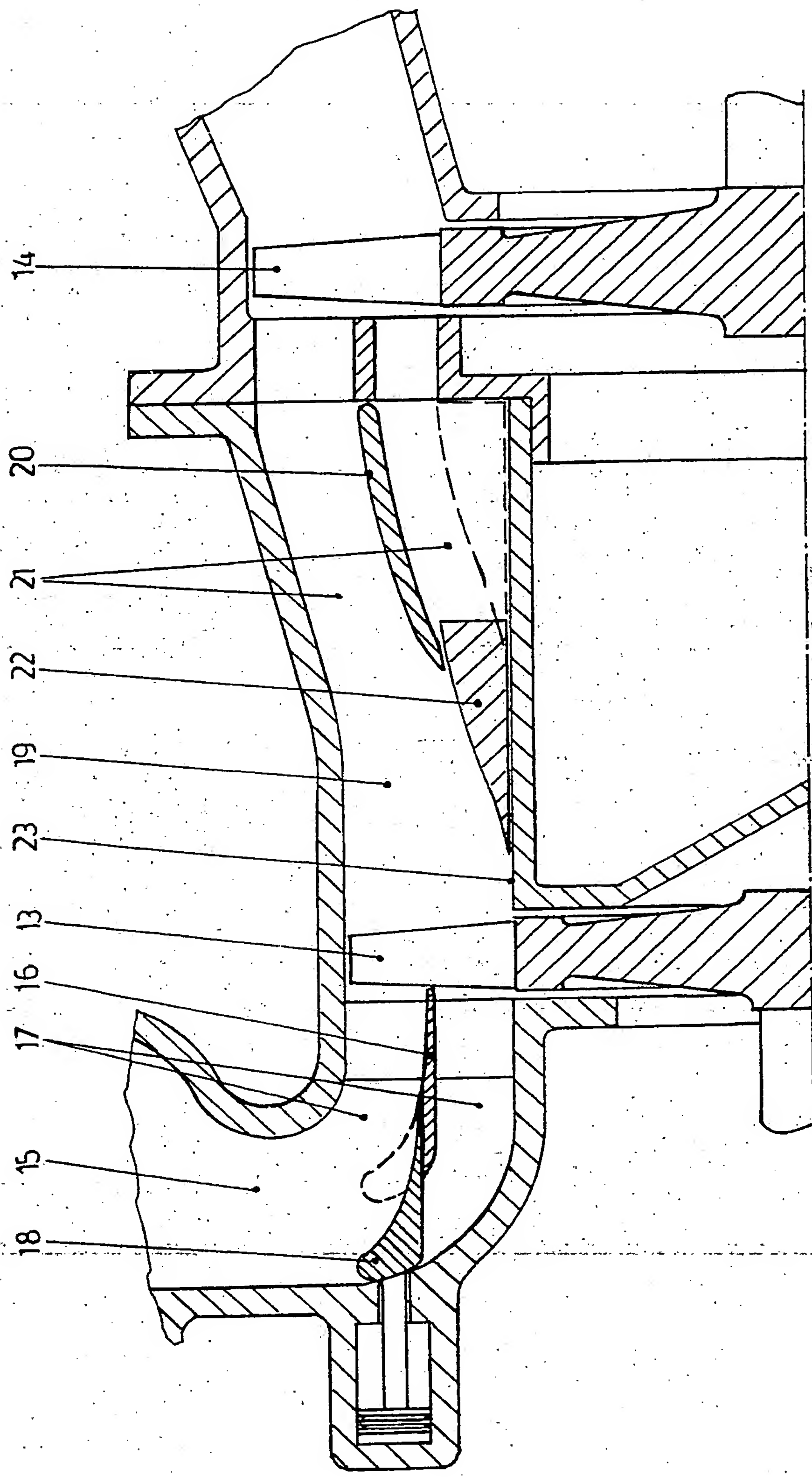


Fig.2

SPECIFICATION

A turbine of an exhaust-gas driven supercharge for an internal combustion engine

This invention relates to a turbine of an exhaust-gas driven supercharger for an internal combustion engine, in which the passage for ducting exhaust gas to the turbine rotor has a partition which divides the inflow passage into sub-channels at least one of which can be opened and closed by means of a shutter element in accordance with the quantity of exhaust gas produced by the engine.

An exhaust-gas driven supercharger of this type is already known from British Patent Specification No. 925 984 in which the exhaust gas inflow passage leading to the exhaust-gas driven turbine is divided into two sub-channels. One of these sub-channels is closed in the event of low rotational speed of the internal combustion engine and/or partial load, so that the exhaust gas is supplied to the turbine through a smaller cross-sectional area than if the entire inflow passage is open, and therefore at high velocity, whereby in this power range an optimum flow of exhaust gas into the turbine is obtained with good acceleration behaviour. On the other hand, with high rotational speed of the internal combustion engine and/or full load, when a greater quantity of exhaust gas is produced at a higher velocity of flow, the admission of exhaust gas to the turbine supplied via one inflow sub-channel only would, on the one hand, produce too high a pressure in front of the turbine, resulting in the danger of bursting and in the strain of too high a rotational speed of the turbine parts and would, on the other hand, produce an undesirably high intake pressure and/or charge air blower outlet pressure. In order to avoid these disadvantages the shutter element which closes the second inflow sub-channel is opened in this operating condition of the internal combustion engine, whereby the pressure of the exhaust gas can be reduced, less critical rotational speed strains are generated in the turbine and the induction pressure required for the engine in the case of full load is obtained.

The shutter element for opening and closing the second inflow sub-channel in British Patent Specification No. 925 984 comprises a poppet valve. However, this method of altering the inflow cross-sectional area produces a substantial resistance to flow in the exhaust gas passage, thus limiting the use of this device to exhaust-gas driven superchargers which do not demand a high degree of efficiency. In particular this closing arrangement of the inflow sub-channel, when using axial-flow-type turbines, represents an unfavourable step in terms of flow technique since here a flow should always be produced, at each position of opening, which flows over the whole periphery of the turbine inlet. In the case of the radial flow turbine the disadvantage exists that a violent impulse change-over occurs with the turbine rotor and the unloaded sub-channel which leads to extensive losses in power efficiency.

An object of the invention lies in the production of a turbine with an inflow channel the construction of which is favourable to flow, in every operational position and involves only low production and maintenance costs.

According to the present invention there is provided a turbine of an exhaust-gas driven supercharger for an internal combustion engine, in which the passage for ducting exhaust gas to the turbine rotor includes an annular partition which divides the inflow passage into sub-channels, and in which there is provided at least one annular shutter mounted coaxially with the annular partition and so as to be displaceable in a direction along its axis, the annular shutter being arranged for movement between a position in which it closes one of the sub-channels so that exhaust gas passes to the turbine rotor via the other sub-channel or channels; and a position in which the said one of the sub-channels is open for the passage of exhaust gas through it to the turbine rotor.

Preferably, the annular shutter comprises an annular slide plate, and the annular partition and the annular slide plate are arranged coaxially with the axis of the turbine.

In an advantageous embodiment of the invention at least two annular partitions are provided which divide the inflow passage into three sub-channels, and the annular shutter or shutters are adapted to close and open at least two of the sub-channels. This results in a particularly large variety of possibilities for admission of exhaust gas to the turbine. For example, the inflow sub-channels lying radially innermost can be closed, whereby the optimum turbine admission can be obtained with very small amounts of exhaust gas with a high velocity of flow. As the amount of exhaust gas increases with increased engine speed or power output the sub-channels located radially innermost can be brought into operation in stages. The flow of exhaust gas into the turbine can thus be influenced in various ways thereby obtaining the desired admission of exhaust gas to the turbine in accordance with the amount of exhaust gas produced.

Furthermore, in using an exhaust-gas driven supercharger with a two-stage turbine, a sub-channel can be directed, by-passing the first turbine stage, to a second turbine stage arranged behind the first stage, by which means the radially outer region of the second turbine stage can be used with a high degree of efficiency.

In a particularly expedient embodiment the annular slide plate can be moved in the

direction of the turbine axis using a screw-thread arrangement.

In the case where the turbine is an axial flow turbine, the turbine blades on the rotor of the turbine are preferably provided with platform partitions extending in the peripheral direction of the rotor and arranged at a radial height on the turbine blades such that they are aligned, in the direction of flow of the exhaust gas through the turbine, with the annular partition or partitions; thus a further annular partition is produced through the rotor as a continuation of the turbine end of the or each annular partition in the inflow passage constituting a fixed ring element. Thus impulse losses in the rotor can be avoided to a large extent by preventing radially extending flow components.

The invention may be put into practice in a number of ways but certain specific embodiment will now be described by way of example with reference to the accompanying drawings, in which:—

Figure 1 is an axial section of a turbine of an exhaust-gas driven supercharger for an internal combustion engine, with a divided inflow casing and two annular slide plates,

Figure 2 is an axial section of a further embodiment of such a turbine with two turbine stages each with an inflow casing, and two different specific constructions of annular slide plates, and

Figure 3 is an axial section of a further embodiment of such a turbine also with two turbine stages, the two turbine stages having a substantially common inflow casing.

Fig. 1 shows an axial flow turbine 1 of an exhaust-gas driven supercharger of an internal combustion engine, having an inflow casing 2 connected to an exhaust-gas manifold (not illustrated) of the engine. This inflow casing 2 contains the inflow channel 3 which, in the region in front of the turbine 1, is divided by partitions 4 into sub-channels 5. At the entrance to the turbine the partitions 4 connect with fixed ring elements 6 which are aligned with platforms 7, forming partitions which extend in a peripheral direction, constructed on the turbine blades of 8 of the turbine rotor.

The inflow channel 3 has radially outer and inner walls 9 and 10 in which annular slide plates 11 and 12, movable in a direction parallel to the turbine axis, are disposed. In the outer wall 9 a screw-thread 12*a* is disposed by which the annular slide plate 12 can be moved axially by rotating it in the direction of its periphery about the axis of the turbine. The rotation can take place by hand using a hand-wheel 12*b* or by using a gearing mechanism (not shown) disposed on the periphery of the annular slide plate, which gearing mechanism has an automatically controlled servomotor.

The axial displacement of the slide plate can alternatively be effected by an electric motor, or by means of fluid pressure as is indicated in the case of the annular slide plate 11 which can be moved by a fluid jack arrangement formed by an annular cylinder 10*a* constructed in the radially inner wall 10 of the turbine casing and an annular piston 11*a* formed on the slide plate 11.

During starting and under partial load of the internal combustion engine, one or more of the sub-channels 5 are closed with one or both of the annular slide plates 11 and 12, so that in this operating condition of the internal combustion engine the exhaust gas is suppled at high velocity to the turbine 1 through only the two or the one of the sub-channels left open. If the power of the internal combustion engine is increased and the amount of exhaust gas produced by it increases accordingly, then the latter can be conveyed through the turbine by a gradual opening of the other sub-channel or sub-channels 5 without an undesirably high compressor outlet pressure (i.e. charging air pressure of the engine) being reached due to increased exhaust gas flow velocities. The two annular slide plates 11 and 12 can, however, be actuated either simultaneously or one after the other, according to which sub-channel 5 is most suitable for the admission of exhaust gas to the turbine 1 given the respective amount of exhaust gas produced and power requirement of the turbine.

Fig. 2 shows a high-pressure turbine 13 and a low-pressure turbine 14 of a two-stage turbine of an exhaust-gas driven supercharger, with two different constructions of the annular slide plates 18 and 22 respectively.

The inflow channel 15 assigned to the high-pressure turbine 13 is divided into two sub-channels 17 by a partition 16. An annular slide plate 18 is arranged axially slidably on this partition 16; in the "open" position (illustrated by broken lines) the slide plate 18 forms a profile with the partition 16 which is favourable to flow and in its other axial position it closes the radially inner one of the two sub-channel 17.

The inflow channel 19 of the low-pressure turbine 14, disposed after the high-pressure turbine 13 relative to the direction of exhaust-gas flow, also has a partition 20 by means of which two sub-channels 21 are formed. The annular slide plate 22 is disposed on the fundamentally cylindrically shaped, radially-inner walll 23 of the inflow channel 19.

The reduction of the turbine inflow cross-sectional area and the closing of one of the sub-channels 21 is achieved by displacement of the annular slide plate 22 on the cylindrical, radially-inner wall 23 in the direction towards the high-pressure turbine 13. In order to improve the efficiency, the blades of the rotors of the turbines 13 and 14 can be provided with partition platforms (not illustrated) (similar to the platforms 7 in Fig. 1)

aligned as continuations of the partitions 16 and 20 respectively.

Fig. 3 shows a further embodiment of the invention for altering the inflow cross-sectional area of the two-stages of the turbine of an exhaust-gas driven supercharger, whereby an inflow channel 24 is divided by partitions 25 into sub-channels 26, 27 and 28, of which two sub-channels 26 and 27 lead to the high-pressure turbine 29 and one sub-channel 28, by-passing the high-pressure stage of the turbine, leads to the radial outer area of the low-pressure turbine 30 arranged behind the high-pressure turbine. The sub-channel 28 on the one hand, and the sub-channels 26 and 27, on the other, can be adjusted to be opened and closed respectively by an annular slide plate 31 and an annular slide plate 32.

Since the flow of exhaust gas is forced radially outwards as a result of the centrifugal effect, the annular passages positioned radially inward are preferably closed at starting and under partial load of the engine so that in the event of partial admission to the turbine with the prevailing amount of exhaust gas an optimum reaction effect on the turbine is achieved.

CLAIMS

1. A turbine for an exhaust-gas driven supercharger for an internal combustion engine, in which the passage for ducting exhaust gas to the turbine rotor includes an annular partition which divides the inflow passage into sub-channels, and in which there is provided at least one annular shutter mounted coaxially with the annular partition and so as to be displaceable in a direction along its axis, the annular shutter being arranged for movement between a position in which it closes one of the sub-channels so that exhaust gas passes to the turbine rotor via the other sub-channel or channels, and a position in which the said one of the sub-channels is open for the passage of exhaust gas through it to the turbine rotor.

2. A turbine as claimed in claim 1, in which the annular shutter comprises an annular slide plate and in which the annular partition and the annular slide plate are arranged coaxially with the axis of the turbine.

3. A turbine as claimed in claim 1 or claim 2, in which two annular partitions are disposed in the inflow passage, which divide the inflow passage into three sub-channels, and in which the annular shutter or shutters are adapted to close and open at least two of the sub-channels.

4. A turbine as claimed in any one of claims 1 to 3, which includes a first turbine rotor constituting a first turbine stage and a second turbine rotor constituting a second turbine stage, and in which one of the sub-channels by-passes the first turbine stage and thereby ducts exhaust gas from the inflow passage direct to the second turbine stage.

5. A turbine as claimed in any one of the preceding claims, in which the or at least one annular shutter is displaceable in a direction along its axis by a screwthreaded arrangement.

6. A turbine as claimed in any one of claims 1 to 4, in which the or at least one annular shutter is displaceable in a direction along its axis by an electric motor.

7. A turbine as claimed in any one of claims 1 to 4, in which the or at least one annular shutter is displaceable in a direction along its axis by a fluid jack arrangement.

8. A turbine as claimed in any one of the preceding claims, which is an axial flow turbine, and in which the turbine blades on the rotor of the turbine are provided with platform partitions extending in the peripheral direction of the rotor and arranged at a radial height on the turbine blades such that they are aligned, in the direction of flow of exhaust gas through the turbine, with the annular partition or partitions.

9. A turbine as claimed in any one of the preceding claims, in which control means is provided whereby the or at least one of the annular shutters is shifted in dependence on changes in the load of the internal combustion engine and/or the rotational speed of the exhaust-gas driven supercharger and the charge air pressure.

10. A method of operating a turbine as claimed in any one of the preceding claims, in which when starting, and during partial load of, the internal combustion, the sub-channel or sub-channels lying radially inwardly of a radially outer sub-channel is/are closed by the annular shutter or shutters.

11. A turbine of an exhaust-gas driven supercharger for an internal combustion engine substantially as specifically described herein with reference to Fig. 1 or to Fig. 2 or to Fig. 3 of the accompanying drawings.

12. An exhaust-gas driven supercharger for an internal combustion engine having a turbine as claimed in any one of claims 1 to 9 or in claim 11.

13. A method of operating a turbine as claimed in claim 11 substantially as specifically described herein.

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